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On Physico-Acoustical Bases of Sonance and Tension

ABSTRACT

Background

Up to the present moment musical science still explains such fundamental phenomena of harmony as sonance and tension by abstract numerical logic in frequency ratios of sounds and by subjectivity and relativity of perception. Those ways of explanation, for instance, are commonly accepted in Russia since they were supported in the book on harmony by Yu. N. Kholopov, the greatest Russian music theorist of the recent times (Kholopov 1988). Besides this, the mathematical logic of sonance was firstly stated by Pythagoreans and later developed by L. Euler (Eulero 1739). And the ultimate expression of the modern 'relativistic' position concerning the tension is concentrated in the aphorism by the Soviet musicologist I. V. Sposobin: 'each tone resolves there where he has gone' (Kholopov 1967). However, this approach seems to have a weak basis cause the musical harmony is the reflection of real acoustic processes, which impact on the perception.

By the way, after the research by Helmholtz (Helmholtz 1863) a variety of implications was made on this problem. In 1929 Orlov (Orlov 1929) showed that objectively the perception of tension depends on tuning of frequency relations. Following the research by Plomp and Levelt (Plomp and Levelt 1965), a renewed model of sonance perception was made by Sethares (1998). However, some questions on this matter still exist now. Above-mentioned works don't touch upon the phenomenon of tension. The most interesting results on the problem of tension are quite obsolete and connected only with the numerical logic of interval progressions in diatonic scale with one pedal tone (Sokalsky 1888). Beside this, the modern theory of tone resonance on the overtones doesn't explain the specifics of sonance perception, which are revealed both in conditions of sounds with soft overtones, and with such sounds as produced by honky-tonk piano.

Meanwhile, the modern physics of nonlinear processes discovers new possibilities in the question of objective explanation of sonance and tension phenomena considering that it deals with the universal laws in dynamic systems including both acoustic systems and homo sapiens as a biological organism (Blekhman 1981; Pikovsky, Rozenblyum and Kurts 2003). The main phenomena which are related with problems of sonance and tension are difference tones and synchronization of oscillations.

Aims and Repertoire Studied

The main objects under consideration are those processes and effects which are produced by interacting sounds in real acoustic conditions. Those are coincidences of waves, beats, overtones, difference tones and their changing in different cases including the case of acting of synchronization. The observation of those phenomena may help to reveal some regularities in relations between physico-acoustical processes and processes of perception of sonance and tension. Such regularities may become the basis for the new model of perception of above-mentioned musical phenomena and renewed explanation of them.

Methods

The initial method of the research consists in direct comparison of regularities of perception and physical phenomena. The result of this comparison makes possible the creation of physical and mathematical models of the processes corresponding to conditions of perception of consonances, dissonances and tensions.

Implications

Specifics of perception of sonance and tension give cause for finding the objective explanations of processes in music which are perceived by ear. The examples of displaying of its regularities have some common features. So, Helmholtz's scheme of frequency of beats in intervals (Helmholtz 1863, 292) shows the curve, which reaches its minima only when the frequency ratio is a rational number. The equivalent scheme was presented by Plomp and Levelt (1965, 556). However, this doesn't mean that the reason of such regularity is connected with coincidences of overtones as it was supposed by Sethares, whose model gives the similar graph (Sethares 1998, 57). The analogous picture may be obtained by using the lower additional tones considering that upper tones may produce only more dissonant effect and make more difficult to detect the harmony. Actually, those lower tones are revealed irrespectively of timbre of given sounds as well as the perception of sonances acts irrespectively of the presence of upper partials. Thus the processes in sonances may regarded on the level of the superposition of waves even if they are presented by sinusoidal waves. The observation of regularities in this superposition shows the production of lower additional tones such as difference tones not only in the conditions of nonlinearity as it is generally thought. But the presence of upper partials makes those tones to be clearer. Modeling of the processes with difference tone gives the similar graphs which associate to well-known mathematical functions such as Tomae's function. The addition of irregularity of real frequencies of sounds makes the curve on the graph to be smoother. However, not to consider the acting of non-linearity seems a great misstep. But this detail gives not only the best explanation of sound effects. The conditions of non-linearity make the effect of synchronization which expresses in tendency of oscillation to come into rational ratios of their frequencies. This fact may be regarded as objective base for explanation of the phenomenon of tension considering that the

effect of synchronization gives the same regularities as in above-mentioned models and is expressed in such special figures on so-called maps of the dynamic modes or circle maps as Arnold tongues (Pikovsky, Rozenblyum and Kurts 2003, 97 and 269). Besides this fact, this effect may allow not only creating physical and mathematical models of perception of music harmony, but also giving such objective characteristics of various cases of phenomena of sonance and tension as level of discordance and energy of tension. Also probably this may be the way to create on an objective basis the theory of analysis of harmony as the process consisting of acoustic events.

Keywords

Sonance, Tension, Synchronization, Difference Tones, Frequency Ratios, Dissonance and Consonance.

REFERENCES

Blekhman, Ilya Izrailevich, 1981. *Synchronization in the Nature and Technologies*. Moscow: Nauka.

Eulero, Leonardo, 1739. *Tentamen novae theoriae musicae ex certissimis harmoniae principiis dilucide expositae.* Petropoli: Ex Typographia Academiae Scientiarum.

Helmholtz, Hermann, 1863. *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik.* Braunsweig: Friedrich Vieweg und Sohn.

Kholopov, Yuri N., 1988. *Harmony: Theoretical Course.* Moscow: Muzyka.

———, 1967 'Lectures and Practical Exercises on Harmony (Based on Student Notes)', in Berkov V. (ed.), *I. V. Sposobin. Musician. Teacher. Scholar*. Moscow: Muzyka, 127–63.

Orlov, Ivan E., 1929. 'On Musical and Acoustic Illusions', in *Issues of Work of Section on Music Acoustics* 2. Moscow: State Edition, Music Sector, 75–83.

Pikovsky, Arkady, and Rozenblyum, Michael, and Kurts, Jürgen, 2003. *Synchronization: The fundamental Nonlinear Phenomenon.* Moscow: Tekhnosfera.

Plomp, Reiner, and Levelt, Willem Johannes Maria, 1965. 'Tonal Consonance and Critical Bandwidth', *Journal of the Acoustical Society of America* 38/4: 548–60.

Sethares, William A., 1998 'Consonance-Based Spectral Mappings', *Computer music journal* 22/1: 56–72.

Sokalsky, Pyotr Petrovich, 1888. *Russian Folk Music, Great Russian and Little Russian in its Structure Melodic and Rhythmic and Distinction of it from the Bases of the Modern Harmonic Music*. Kharkov: Typ. A. Darre.